Influences of Liming on Field Crop Yields and Plant Available Zinc Status in Soil

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INTRODUCTION

Soil acidity is in many cases a limiting factor for the yield of arable crops in Croatia. Liming acidic soils is usually recommended for their improvement. Liming was reported first in Croatia more than 200 years ago (Radic 1989). Naturally occuring minerals commonly used to raise soil pH are limestone and dolomite. Also, waste products from manufacturing processes can be used to neutralize soil acidity. However, nutritional imbalances, especially decreases of Zn uptake by plants, can be caused by liming. Cakmac (1999) reported that Zn deficiency is a serious problem in plant and human nutrition.

METHODS

Field experiment with increased rates of carbocalk (waste of Osijek Sugar Factory: 34.4% Ca, 6.33% humus, pH = 9.53, plant available Zn determined by Ammonium Acetate – EDTA extraction = 38.5 mg Zn kg^{-1}) were started on November 8, 2000 on arable land of Kutjevo Agricultural Holding (Pozega-Slavonian County). The soil was characterized as a stagnic albeluvisol (FAO Classification) with a Ap-E/E-Btg-C profile. Carbocalk treatments were 0, 15, 30, 45, 60 and 90 t ha^{-1}. The field trial was conducted in four replicates (experimental plot of fertilization $64.26m^2$ = 8.4 x 7.65m). Crop rotation for 2001-2004 period was maize (2001) – maize (2002) – sunflower (2003) – winter barley (2004). Yields were reported by Kovacevic et al. (2006).

Soil samples were taken from each plot (July 24, 2004; total of 24 mean samples) by auger up to 30 cm of depth. A mean sample contained 15 individual samples. The mobile soil fractions of Zn was extracted by Ammonium Acetate –EDTA solution (pH 4.65) according to Lakanen and Ervio (1971). Statistical calculations were made according to Mead et al. (1996).

RESULTS AND DISCUSSION

Liming with carbokalk resulted in considerable increases of field-crop yields. Liming increased maize yields up to 50 and 36%, in the 2001 and 2002 growing seasons, respectively. Sunflowers also responded to liming with yield increases. The optimal treatment level was 45 t of lime ha^{-1}. Using the lowest lime rate resulted in an increase of 30% for barley yield (Table 1).

As affected by the treatments, pH (1N KCl) increased from 3.89 (control) to 7.30. At the same time, available Ca increased from 568 to 4736 mg Ca kg^{-1}. Increasing of soil pH values reduced plant-available Zn concentrations considerably in the 0-30 cm soil layer. However, differences in mobile soil-Zn concentrations were non-significant among liming treatments (Table 1). Zinc deficiency mainly occurred in soils with high pHs, especially in calcareous soils (Rastija et al. 2001). Also, cultivars of the same species may differ markedly in their potential to exploit soil Zn (Cakmak et al. 1997). In general, Zn concentrations in the grain of winter barley were low, and differences among liming treatments were non-significant. However, the P:Zn ratio considerably increased with liming mainly due to increased P concentrations (Table 1).

In some cases, genetical influences could be more important for the Zn nutrition in plants than influences by liming. Kovacevic et al. (2004) tested the response of twenty corn hybrids on acid soil. Five hybrids (group A: OsSK378, OsSK298, OsSK321, OsSK277 and Clarika) had lower values of P: Zn ratios (mean 109) in both years in comparison with the second group (mean 188) of five hybrids (group B: Alpos, OsSK395, Bc278, Os247 and OsSk382).

Table 1: Influences of liming (2000) on yields (2001-2004) and soil status (July 2004).

	Liming with carbocalk (t/ha: November 8, 2000)						LSD	
	0	15	30	45	60	90	5%	1%
	Soil status of surface area (0-30 cm) at July 2004							
pH (H_2O)	5.33	5.81	6.52	7.12	7.35	7.72	0.25	0.34
pH (1nKCl)	3.89	4.71	5.80	6.62	6.95	7.30	0.32	0.44
Humus (%)	1.98	1.83	1.93	1.98	1.92	1.67	0.18	n.s
P_2O_5 mg kg^{-1}	132	125	152	185	178	243	30	42
Ca (mg kg^{-1})	568	1143	1504	2140	2484	4736	292	405
Mg (mg kg^{-1})	74	86	90	102	98	103	12	16
Zinc (mg Zn kg^{-1})	1.52	0.95	0.62	0.75	0.69	0.64	0.45	0.62
	Grain yields (t ha^{-1}) of field crops (Kovacevic et al. 2006)							
Maize (2001)	5.04	6.19	6.39	6.72	7.56	4.46	1.05	1.47
Maize (2002)	5.51	6.66	6.77	6.82	7.50	5.08	0.92	1.38
Sunflower (2003)	2.72	3.77	4.04	3.46	3.31	2.83	0.41	0.56
Winter barley (2004)	5.79	7.50	7.29	6.82	7.05	6.51	0.76	1.06
	Grain (2004) composition of winter barley							
Phosphorus (mg P kg^{-1})	3499	4210	4465	4658	4650	4571	352	488
Zinc ((mg Zn kg^{-1})	17.7	18.4	21.1	22.4	21.4	17.9	n.s.	
P:Zn ratio	198	229	212	208	217	255		

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